

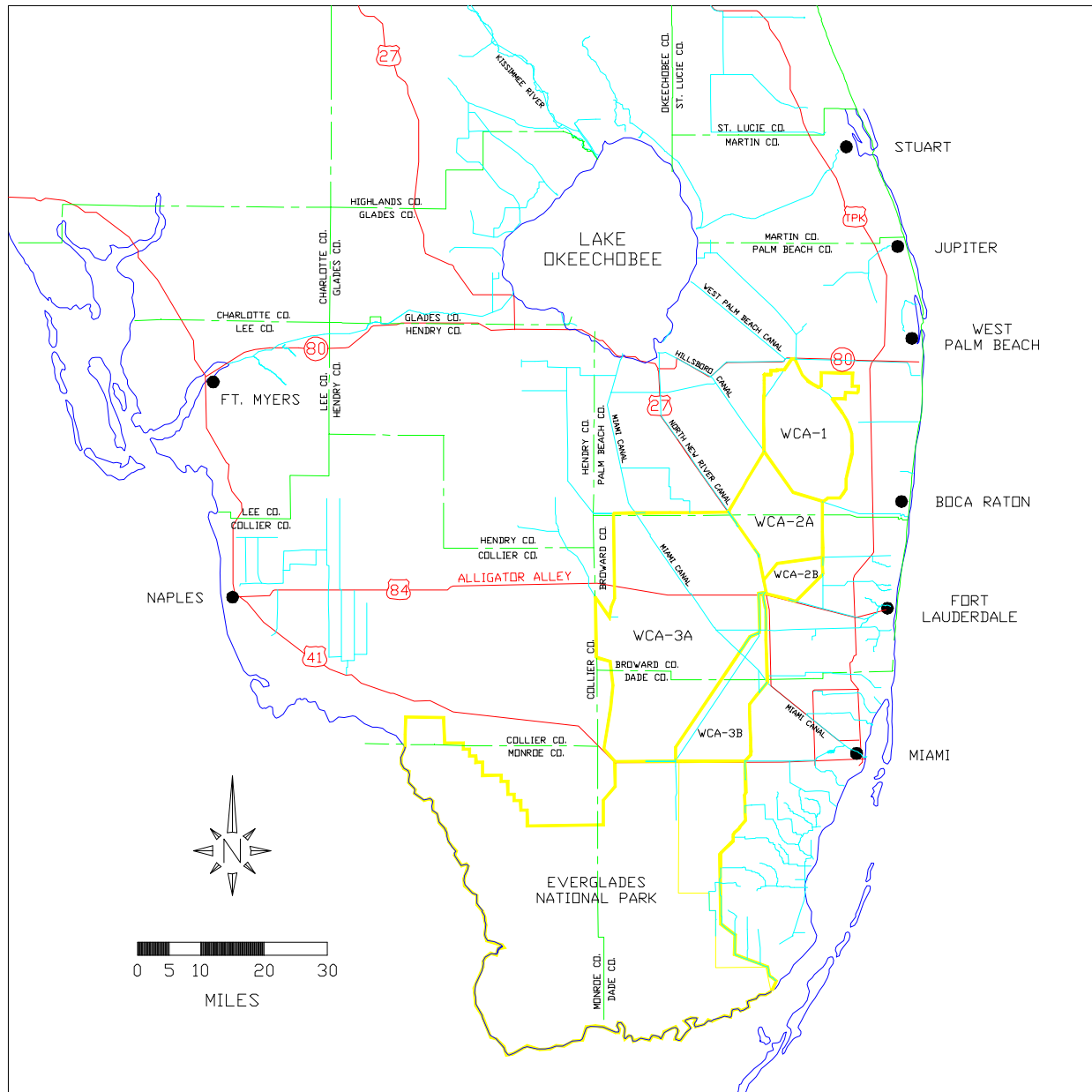
## **3.4 EVERGLADES PROTECTION AREA**

### **Introduction**

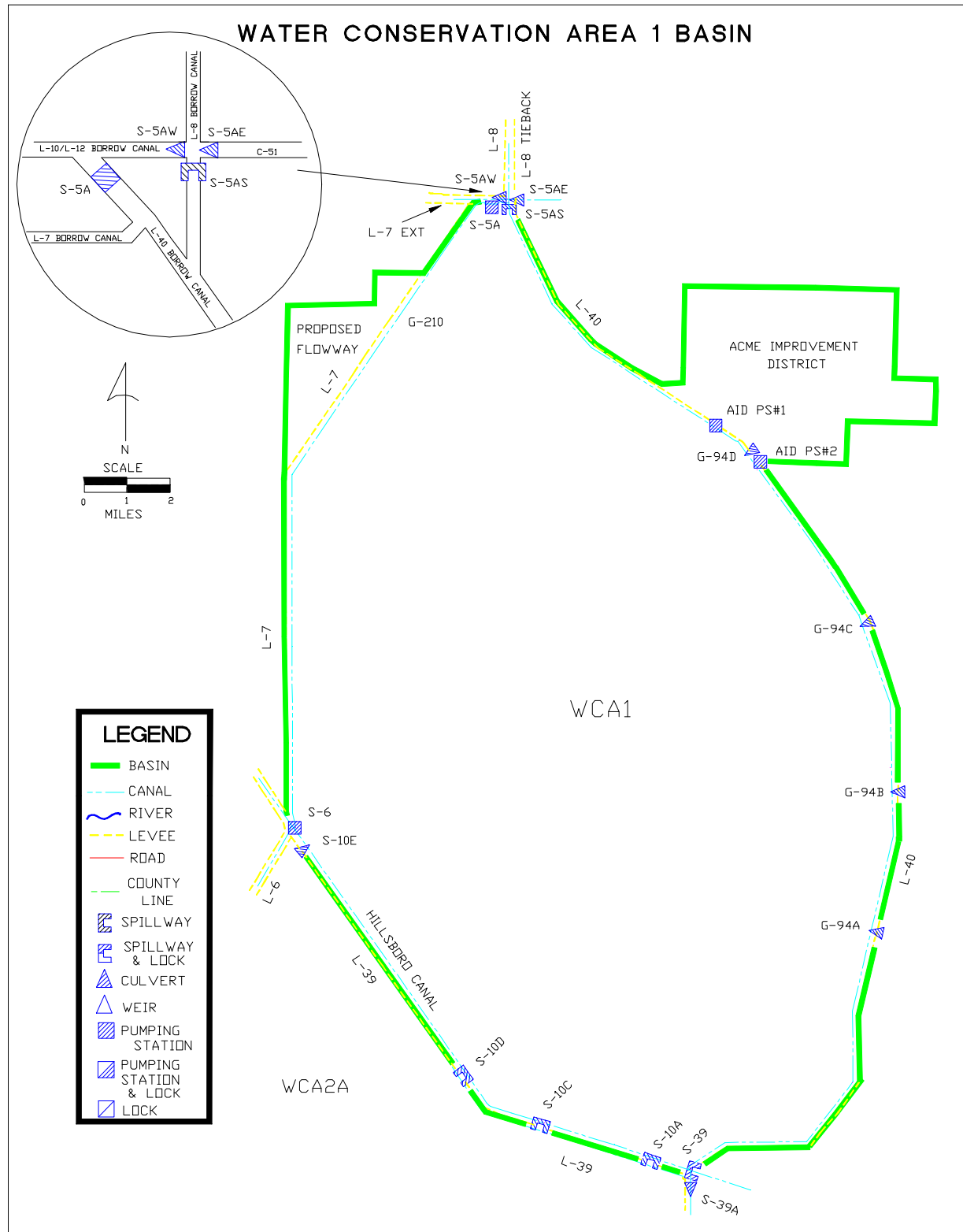
The Water Conservation Areas (WCA-1, WCA-2A, WCA-2B, WCA-3A and WCA-3B) comprise five surface water management basins in the Everglades. Bounded by the Everglades Agricultural Area on the north and the Everglades National Park basin on the south, the WCAs are confined by levees and water control structures that regulate the inflows and outflows to each one of them. In general, they were designed: (1) to provide viable wetland habitat; (2) to receive excess water from the Everglades Agricultural Area; (3) to receive regulatory releases from Lake Okeechobee; (4) to prevent flood water from accumulating in the Everglades and from flooding urban and agricultural lands in eastern coastal areas; (5) to recharge regional groundwater; (6) to store water for dry season water deliveries to eastern Dade, Broward, and Palm Beach counties for agricultural and municipal water supply; and (7) to control saltwater intrusion into the groundwater. All WCAs are jointly owned by the state and the District. The U.S. Fish and Wildlife Service (USFWS) manages WCA-1 while the District and the Florida Game and Freshwater Fish Commission (FGFWFC) jointly manage WCA-2 and WCA-3. The Everglades National Park (ENP), on the other hand, is operated by the National Park Service and is located on the southern tip of the Florida peninsula. A schematic showing the boundaries of the WCAs and the ENP is shown in Fig. 3.4.1. The WCAs and the ENP region is commonly known as the EPA or Everglades Protection Area (SFWMD, 1992).

Water Conservation Area 1 is part of the Arthur R. Marshall Loxahatchee National Wildlife Refuge. It has an area of 242.7 square miles and is located entirely within south-central Palm Beach county. Fig. 3.4.2 shows a schematic of WCA-1 basin boundary, canals and water control structures. WCA-1 has six primary functions (Cooper and Roy, 1991). They are:

1. to provide viable wetland habitat;
2. to detain and store flood and drainage water during the wet season for water supply during the dry season;
3. to prevent water accumulating in the Everglades from overflowing into urban and agricultural lands in eastern Palm Beach county;
4. to receive and store releases from Lake Okeechobee;
5. to provide conveyance of water supply releases from Lake Okeechobee to the Hillsboro canal basin; and
6. to supply water to eastern Palm Beach and Broward counties.



**Figure 3.4.1** Surface Water Management Basins in the Everglades: Water Conservation Areas and Everglades National Park (adapted from Cooper and Roy, 1991)



**Figure 3.4.2** WCA-1 Basin Boundary, Canals and Water Control Structures (adapted from Cooper and Roy, 1991)

Water Conservation Area 2 (WCA-2A and WCA-2B, also known as Sawgrass Recreational Area), comprising 210 square miles, is located immediately south of WCA-1. Originally constructed as a single area, this WCA was divided by a levee, L-35B, constructed in 1961 to allow better control of water levels as a consequence of reduction in seepage losses out of the entire area. WCA-2A has an area of 164.7 square miles and is located in the south-central portion of Palm Beach county and the north-central portion of Broward county. It has ground elevations ranging from 13 ft NGVD in its northern tip to around 7 ft NGVD at its southern end. Water levels in WCA-2A are normally regulated between 13.0 and 14.5 ft NGVD as of the early 1980's. Water enters the area across the Hillsboro Canal from WCA-1 on the northeast side, and across the North New River Canal on the northwest side. Water is discharged from WCA-2A through structures into Cypress Creek Canal (C-14), North New River Canal, and WCA-2B. This water conservation area has five primary functions (Cooper and Roy, 1991). They are:

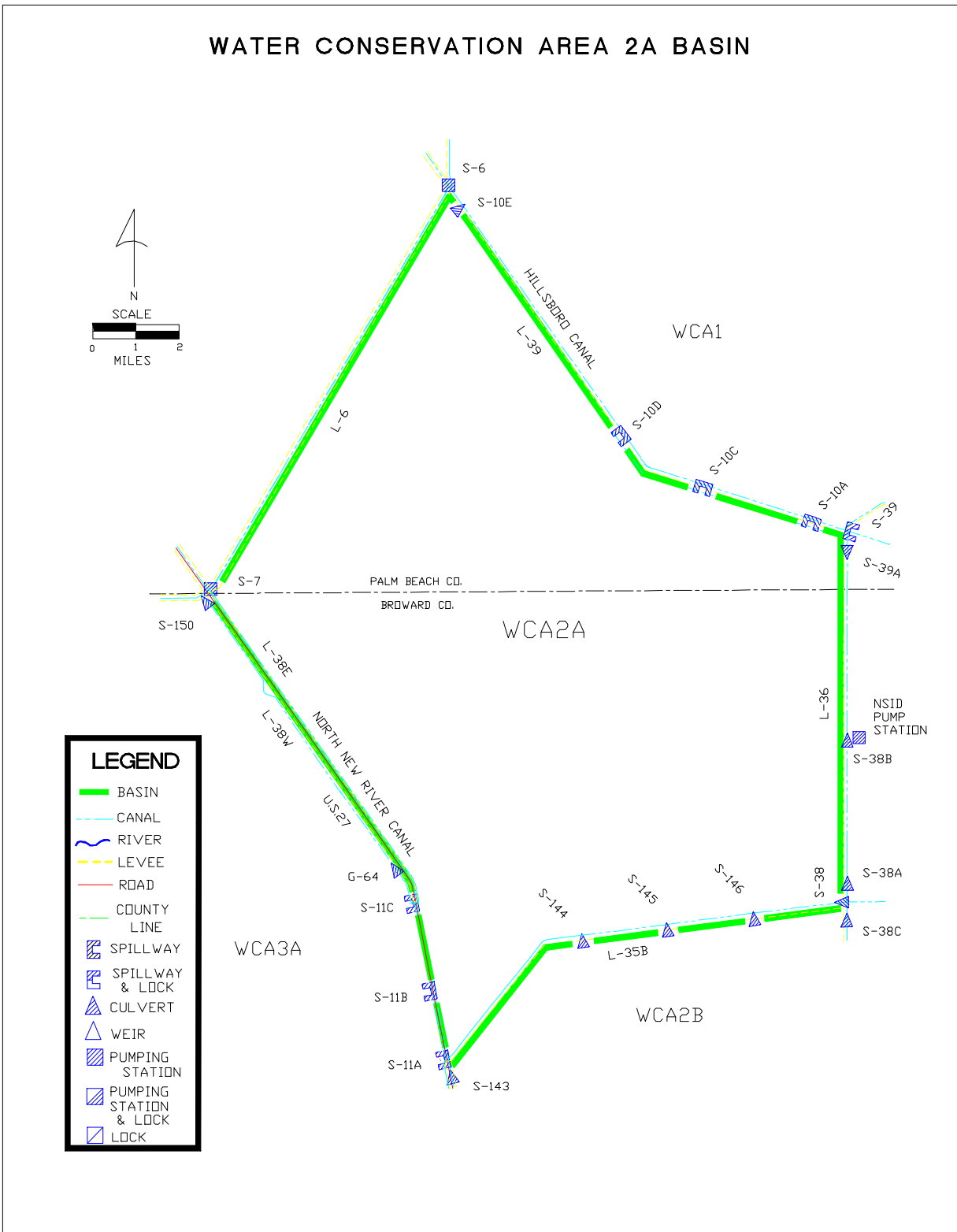
1. to provide viable wetland habitat;
2. to store flood and drainage water during the wet season for subsequent use during the dry season;
3. to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Broward county;
4. to receive and store regulatory releases from Lake Okeechobee and WCA-1; and
5. to provide conveyance for water supply releases from Lake Okeechobee to eastern Broward county.

Figure 3.4.3 shows a schematic of WCA-2A basin boundary, canals and water control structures.

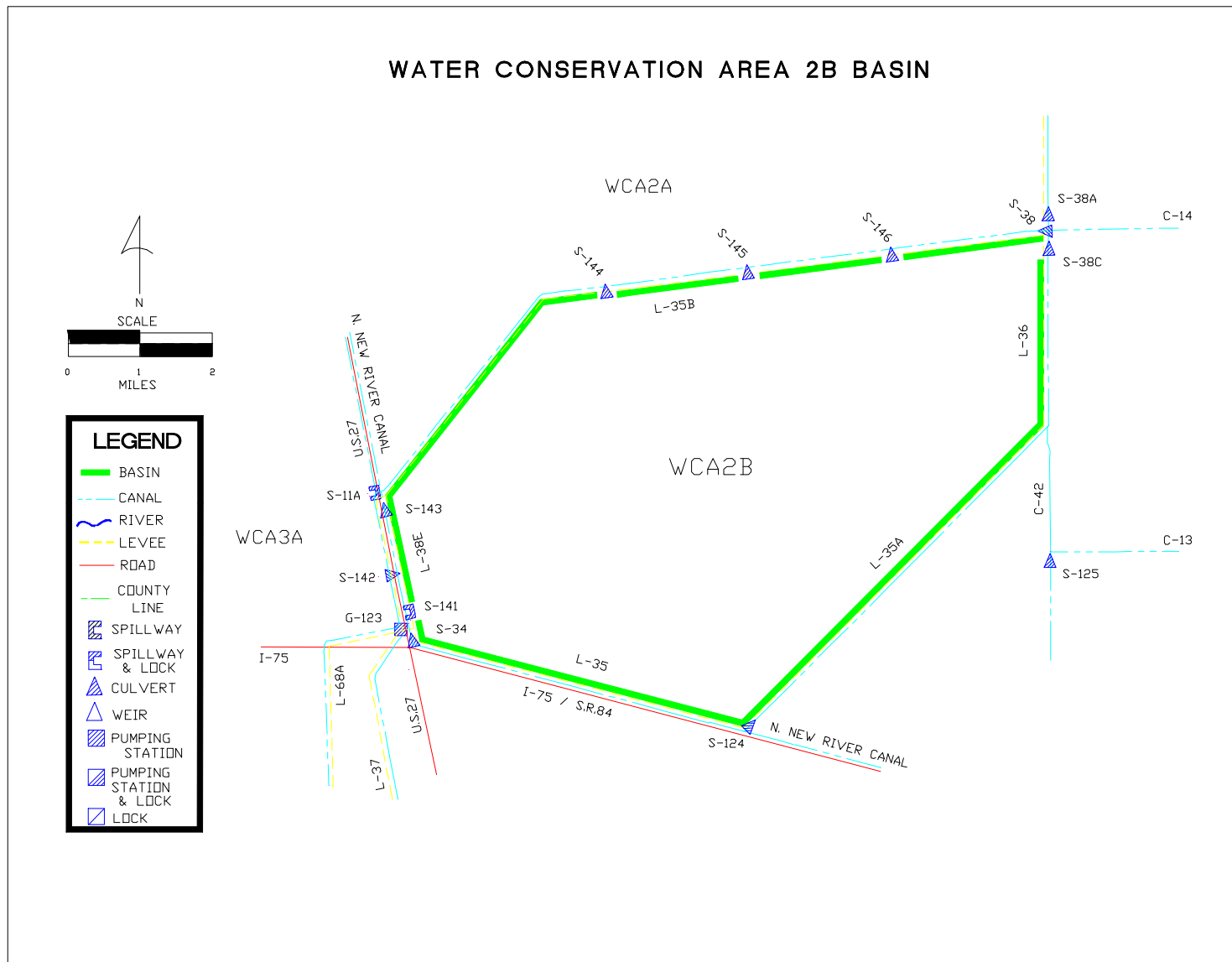
WCA-2B has an area of 43.8 square miles and is located in the central portion of Broward county. It has ground elevations ranging from 9.5 ft NGVD in the northern portions down to about 7.0 ft NGVD in the southern portions of the area. Long term storage of water in this water conservation area is not possible due to high seepage rates. Releases from WCA-2B are not normally done. This water conservation area has five primary functions (Cooper and Roy, 1991). They are:

1. to provide viable wetland habitat;
2. to recharge regional groundwater (in the Biscayne Aquifer);
3. to supply water to adjacent basins in Broward county;
4. to receive and store regulatory discharges from WCA-2A; and
5. to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Broward county.

Figure 3.4.4 shows a schematic of WCA-2B basin boundary, canals and water control structures.



**Figure 3.4.3** WCA-2A Basin Boundary, Canals and Water Control Structures (adapted from Cooper and Roy, 1991)



**Figure 3.4.4** WCA-2B Basin Boundary, Canals and Water Control Structures (adapted from Cooper and Roy, 1991)

Water Conservation Area 3 (WCA-3A and WCA-3B) consists of 1,015 square miles. It is divided into two subareas by the L-67 borrow canals which run northeast to southwest cutting across the Broward-Dade county line. WCA-3A has an area of 767.3 square miles and is located in western Broward County (568.4 square miles) and in northwestern Dade County (198.9 square miles). The ground elevations in this area range from about 13 ft NGVD in the northern section to around 7 ft NGVD in the southern portion. Water levels are normally regulated between 9.5 and 10.5 ft NGVD by releases from structures along the southern border of the area. Inflow to this water conservation area comes from several northern basins and canals. WCA-3A has five primary functions (Cooper and Roy, 1991). They are:

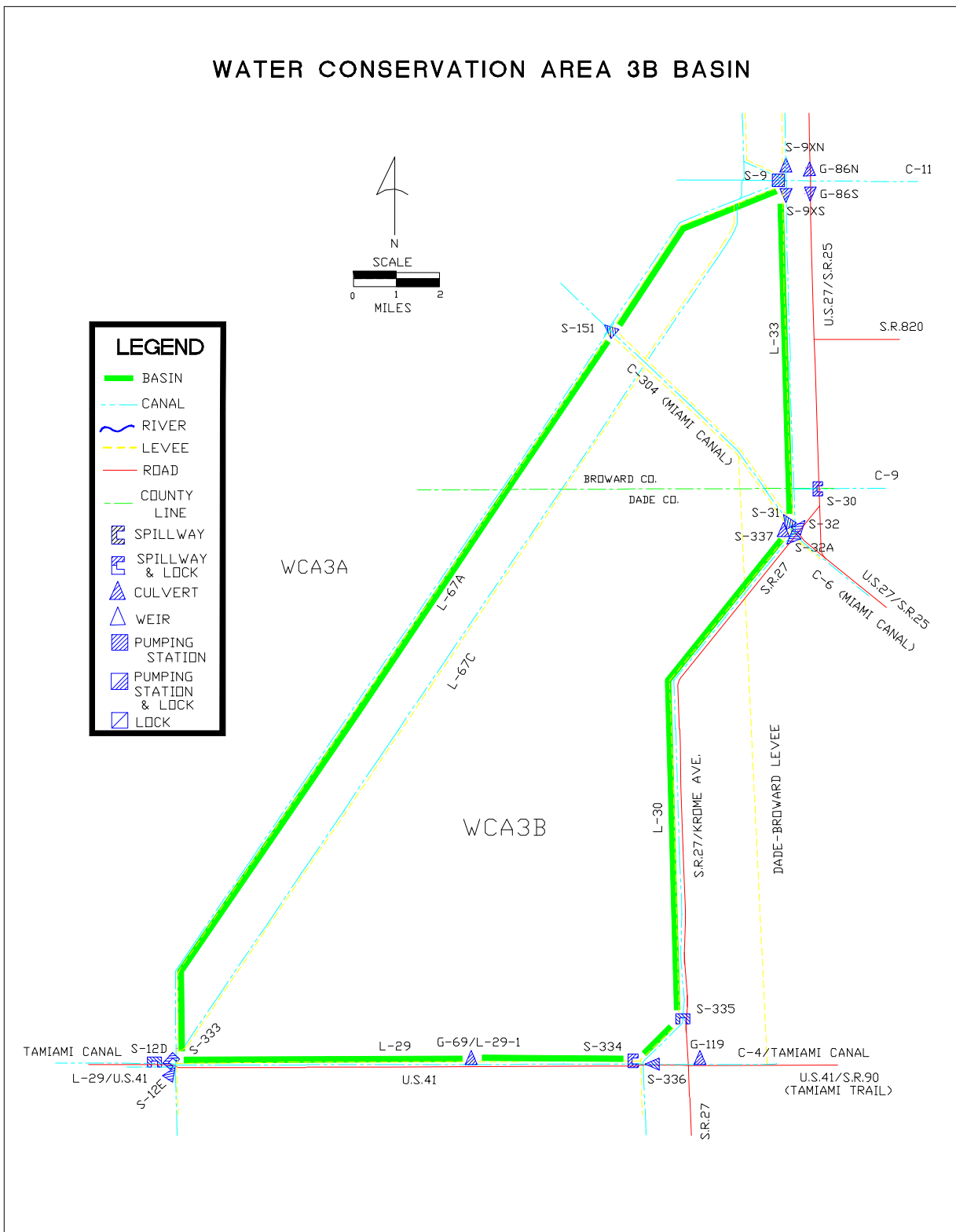
1. to provide viable wetland habitat;
2. to store flood and drainage water during the wet season for water supply for subsequent use in the dry season;
3. to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Dade and Broward counties;
4. to receive and store regulatory releases from Lake Okeechobee and WCA-2A; and
5. to provide conveyance for water supply releases from Lake Okeechobee to eastern Dade County and the Everglades National Park via the South Dade Conveyance System (SDCS).

Like WCA-2B, WCA-3B (a.k.a. Francis Taylor Wildlife Management Area) has no regulation schedule due to its high seepage rate. Figures 3.4.5 and 3.4.6 show schematics of WCA-3A and WCA-3B basin boundaries, canals and water control structures, respectively.

The surface water management basin defined by the Everglades National Park has an area of 1,684.5 square miles. The extent of the ENP covers three counties in the state: Dade county (886.5 sq mi), Monroe county (773.9 sq mi), Collier county (24.1 sq mi). The peripheral structures around the basin are primarily used for water supply to the basin. The Rainfall Plan for ENP (Neidrauer and Cooper, 1989) was developed to allow a more "natural" passage of overland flow into the park. It was based on a statistical model, developed by the District and in cooperation with the Corps and ENP, that correlates upstream weather conditions to the amount, timing and distribution of flows to the ENP. Figure 3.4.7 shows a schematic of ENP basin boundary, canals and water control structures.







**Figure 3.4.6** WCA-3B Basin Boundary, Canals and Water Control Structures (adapted from Cooper and Roy, 1991)

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## Model Implementation

The model represents the Everglades Protection Area as a system of homogeneous 2-mile by 2-mile grid cells. The grid network shown in Figure 3.4.8 delineates the five WCAs and Eastern Everglades National Park from the rest of the model. (note: ENP-East corresponds to the portion of ENP within Dade county.) Separate water budgets can be prepared for the six water management basins shown in this figure. A comparison between the actual and modeled areas in the EPA is depicted in Table 3.4.1.

**Table 3.4.1** Comparison Between Actual and Modeled Areas in the Everglades Protection Area

Everglades Protection Area Water Budget Basin	Area as Defined in the Everglades SWIM Plan (1992), sq mi	Area as Modeled in the SFWMM, sq mi
WCA-1	227	228
WCA-2A	173	164
WCA-2B	37	44
WCA-3A	786	772
WCA-3B	128	108
ENP-East	886.5*	824 <sup>#</sup>

note: \* Data from Everglades Atlas, 1991.

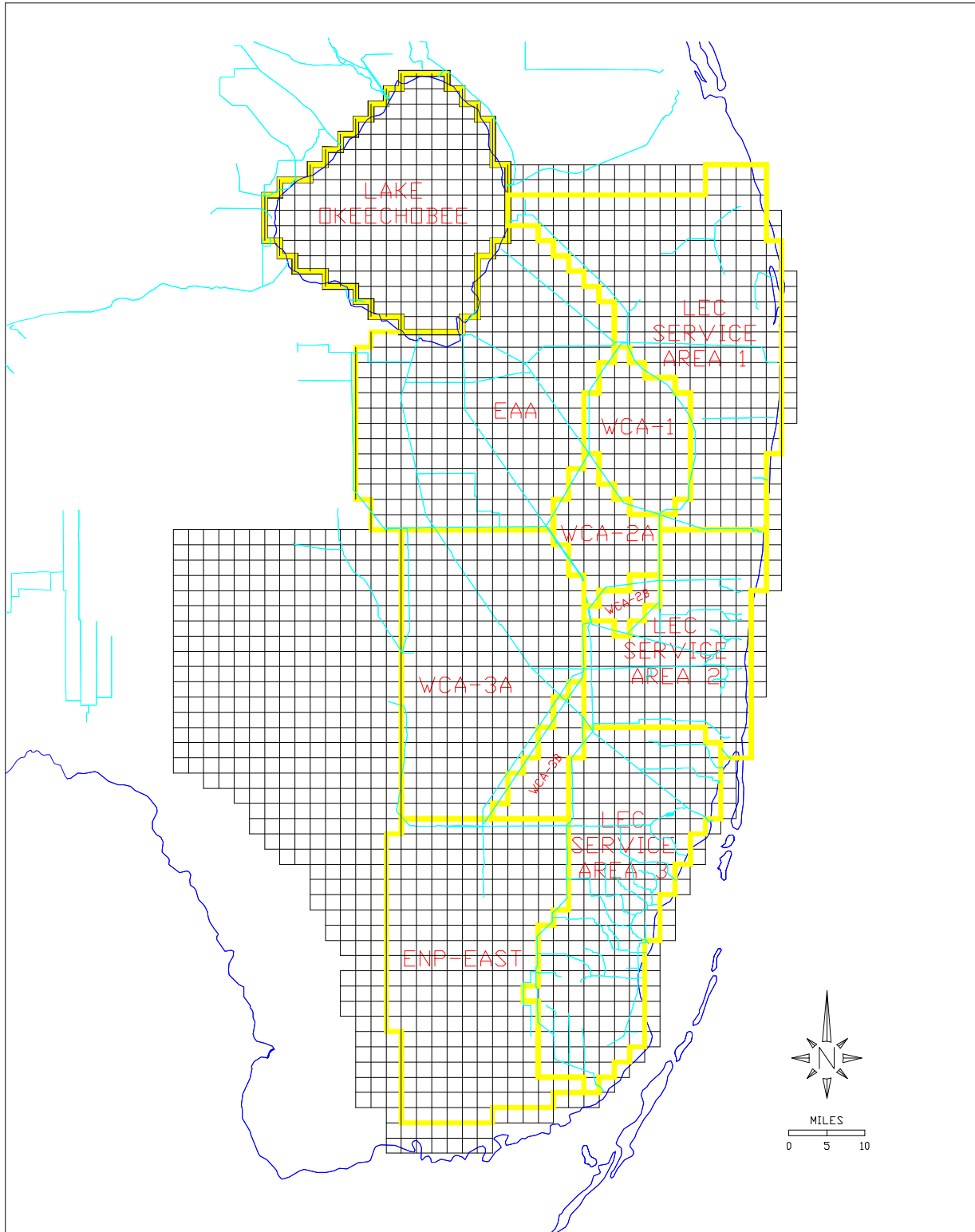
<sup>#</sup> Does not include model boundary grid cells.

## Operating Rules

Similar to Lake Okeechobee, the operating rules governing the management of the Water Conservation Areas may be classified into three categories: regulatory (flood control) , water supply (exclusively to LEC service areas) and environmental (proposed flow and/or stage targets in the Water Conservation Areas). Water used for environmental purposes can sometimes be classified under water supply. The rules governing these types of releases are closely related. Initially, a list of outlet and inlet structures will be given as a function of release type (regulatory or water supply). Then, a discussion of structure operations for both release types will be presented. Lastly, the proposed environmental release rules will be summarized.

## WCA Structures for Regulatory and Water Supply Discharges

A WCA outlet structure, in general, can be identified either as a water supply or flood control structure. In the SFWMM, water supply releases are made first before flood control releases are done.



**Figure 3.4.8** SFWMM Grid Cell Network with Model Boundary and Water Budget Basins Superimposed on a Map of South Florida with Major Canals

The following WCA outlet structures and their specific usage are simulated in the model.

**A. WCA-1:**

1. Water Supply

S-39 to Hillsboro Canal in LEC and appropriate Lake Worth Drainage District (LWDD) canals in order to meet demands not met by G-94A & B

G-94 A and B to LWDD

G-94 D to Acme Improvement District

S-5AS into L-8 and M-canal to meet demands-not-met by LOK

S-5AS into C-51 and appropriate LWDD canals in order to meet demands not met by G-94A & B

2. Regulatory (Flood Control)

S-39 (optional)

S-10 A, C and D

S-10 E

**B. WCA-2A:**

1. Water Supply

S-34

S-38

2. Flood Control

S-38 (optional)

S-34 (optional)

S-144

S-145

S-146

S-11A, B, and C

**C. WCA-3A:**

1. Water Supply

S-151

2. Flood Control/Rainfall Plan

S-12s

S-151

S-333

S-343 A and B

S-344

Structures S-39, S-38 and S-34 are typically used for water supply. However, there is an option in the model to pass regulatory discharges through S-39 into the Hillsboro Canal from WCA-1, and regulatory discharges through S-38 and S-34 into coastal Broward county from WCA-2A.

SFWMM considers the following inlet structures into the WCAs.

**A. WCA-1:**

S-5A complex from EAA (with the exception of S-5AE)

S-6 from EAA

Inflow from Acme Improvement District

Runoff from L-8 Basin through S-5AS

(Only if the L-8 canal stage is greater than the rim canal stage in WCA-1)

Runoff from L-8 basin via S-5AW and S-5A pumps into WCA-1

**B. WCA-2A:**

S-7 from EAA

**C. WCA-3A:**

S-8 from EAA

S-9 from C-11 in Eastern Broward County

S-140A from Western Basins  
S-150 from EAA  
S-190 thru L-28 Interceptor Canal

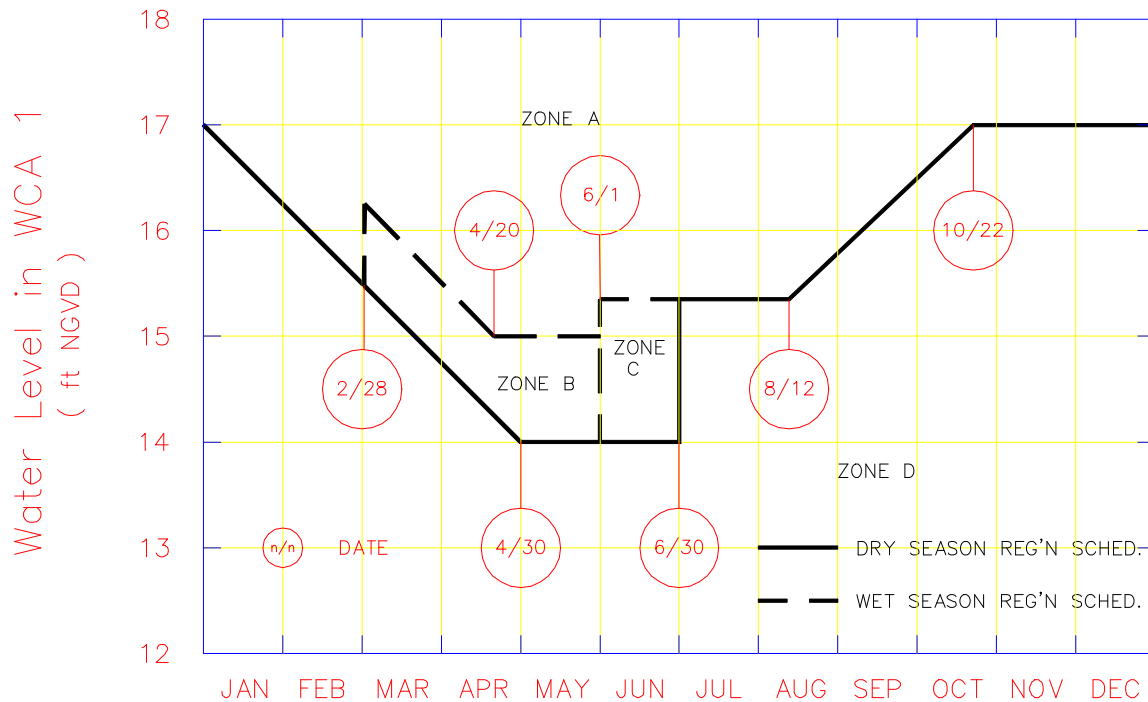
Figures 3.4.9 through 3.4.11 show the current regulation schedules for WCA-1, WCA-2A and WCA-3A, respectively, as provided by the Corps (USACE, 1992). Figure 3.4.12 is a composite display of the three regulation schedules. A common feature among these schedules is that certain monitoring points (observation wells or canals) trigger flood control releases when the stage exceeds a certain threshold or maximum level. A summary of the trigger locations including model grid cell locations in (column,row) coordinates for regulatory releases from WCAs is listed in Table 3.4.2.

**Table 3.4.2** Trigger Locations for Regulatory Releases from WCAs as Used in the SFWMM

Water Conservation Area	Trigger Location
WCA-1	Arithmetic average of 1-8T (34,47), 1-7 (31,48) and 1-9 (33,46) when the average simulated stage of location is greater than 15.5 ft.  1-8C (L-40 borrow canal stage), otherwise
WCA-2A	2A-17 (29,40) when simulated stage at location is greater than 11.5 ft.  L-38 borrow canal, otherwise
WCA-3A	3-gage average, i.e., arithmetic average of 3A-3 (25,37), 3A-4 (21,29) and 3A-28 (19,24)

In the model, some regulation zones are collapsed into single zones, thus simplifying the implementation of flood control releases from the WCAs. For example, zones B and D in the regulation schedule for WCA-1 require some forecasting capabilities which are not included in the model. Thus, the model only considers the top trace of WCA-1 regulation schedule (Fig. 3.4.9). Flood control releases out of WCA-2A and WCA-3A closely follow the schedules prescribed by the Corps (Figures 3.4.10 and 3.4.11). The flood control or regulatory release rules for WCA-3A are shown in Fig. 3.4.11. Also, a tabular summary of the structure operations in the WCAs for regulatory discharges as implemented in the model is shown in Table 3.4.3.

In a given day, the model normally assumes that the amount of regulatory discharge out of a particular water conservation area is limited by the volume of water above a certain level (typically the schedule itself) within the corresponding peripheral borrow canal. For WCA-1 and WCA-2A, the maximum drawdown of the canal for regulatory releases is assumed to be 0.5 feet below regulation schedule if the stage in the gaging station is used as trigger. On the other hand, if canal stage is used as trigger, then the maximum drawdown of the canal stage is assumed to be equal to the regulation schedule.

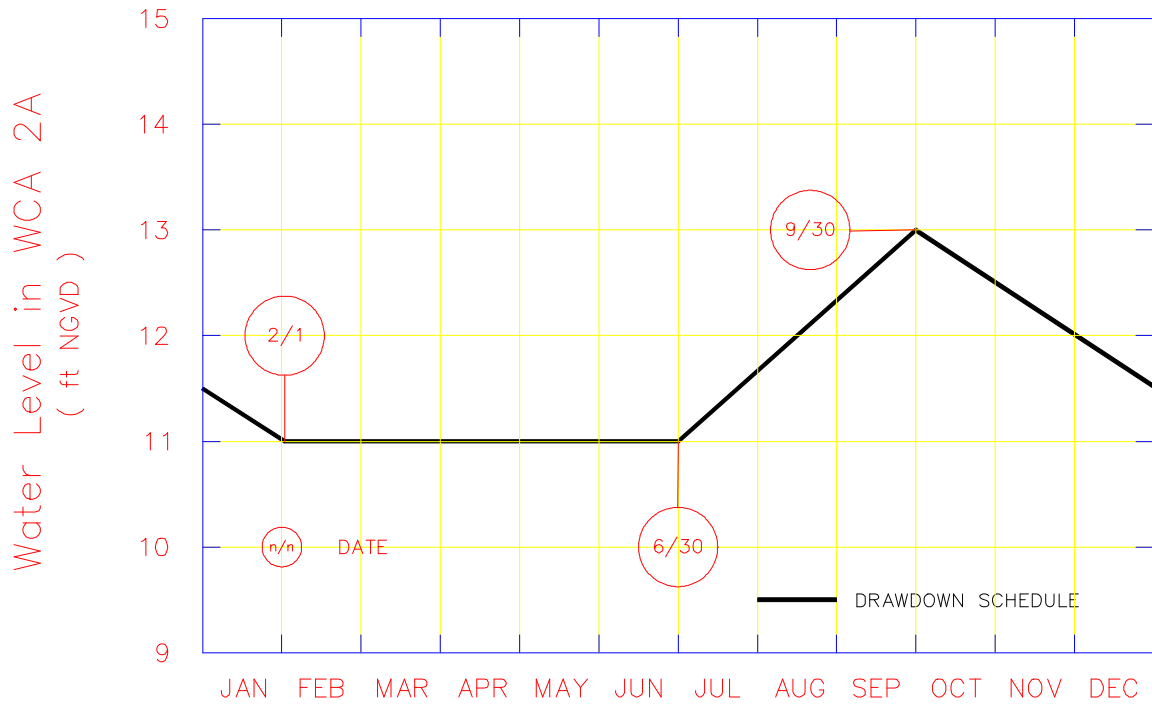


ZONE	RELEASES
A	UP TO MAXIMUM AT S-10 (AND S-39 WHEN AGREED).
B	UP TO MAXIMUM BASED ON 30-DAY FORECAST. IF STAGE EXCEEDS ZONE B, ELEVATION 14.0 IS FOREGONE FOR YEAR, DASHED LINE IS SCHEDULE.
C	STAGE ALLOWED TO RISE IN THIS ZONE IF ELEVATION 14.0 OR BELOW OBTAINED FOR 30 DAYS.
D	WATER SUPPLY ONLY.

- NOTES: (1) WHEN OPERATING NEAR ZONE LIMITS, 30-DAY FORECAST USED TO DETERMINE DISCHARGE RATE.
- (2) NO RELEASES PERMITTED WHEN 1-8 CANAL GAGE READING FALLS BELOW ELEVATION 11.0, UNLESS WATER IS SUPPLIED FROM ANOTHER SOURCE.
- (3) INDICATOR GAGES FOR REGULATION WILL BE AS FOLLOWS: TRANSITION TO BE MADE WHEN CANAL STAGE EQUALS AVERAGE STAGES WHEN POSSIBLE TO AVOID DISCONTINUITIES.

DATES	USE GAGE	CONDITIONS
1 JAN - 30 JUN	1-8 CANAL	ALL
1 JUL - 31 DEC	1-8 CANAL	EXCEPT AS NOTED BELOW
	AVG. 1-7, 1-8T, 1-9	DURING RISING STAGES WHEN CANAL STAGE EXCEEDS AVERAGE.

**Figure 3.4.9** Regulation Schedule for Water Conservation Area 1 (adapted from U.S. Army Corps of Engineers, 1992)



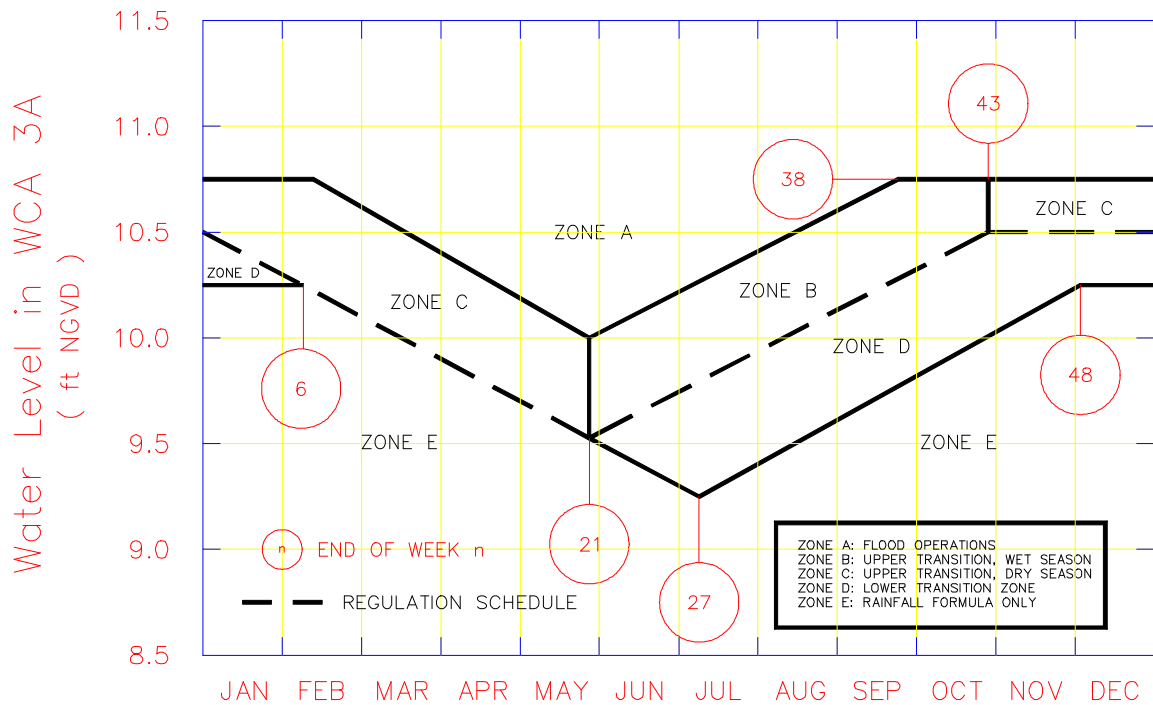
ZONE	RELEASES
A	UP TO MAXIMUM AT S-11; MAXIMUM CAPACITY AT S-144, S-145 AND S-146; MAXIMUM PRACTICABLE AT S-143 AND S-38 WHEN REQUESTED BY THE CORPS OF ENGINEERS, BUT NOT TO EXCEED 11.0 FEET, NGVD, IN POOL 2B. L-35B AND L-38 BORROW CANALS SHOULD NOT BE DRAWN DOWN BELOW 10.5 FEET, NGVD.
B	WATER SUPPLY. L-35B AND L-38 BORROW CANAL SHOULD NOT BE DRAWN DOWN BELOW 10.5 FEET, NGVD, UNLESS WATER SUPPLIED FROM ANOTHER SOURCE.

INDICATOR GAGES FOR REGULATION WILL BE AS FOLLOWS:

DATES	USE GAGE	CONDITIONS
1 JAN - 31 JAN	2-17	IF 2-17 STAGE RECEDES TO 11.5 FEET, NGVD SWITCH TO S-11B HEADWATER GAGE.
1 FEB - 30 JUN	S-11B	ALL
1 JUL - 31 DEC	2-17	ALL

**Figure 3.4.10** Regulation Schedule for Water Conservation Area 2A (adapted from U.S. Army Corps of Engineers, 1992)

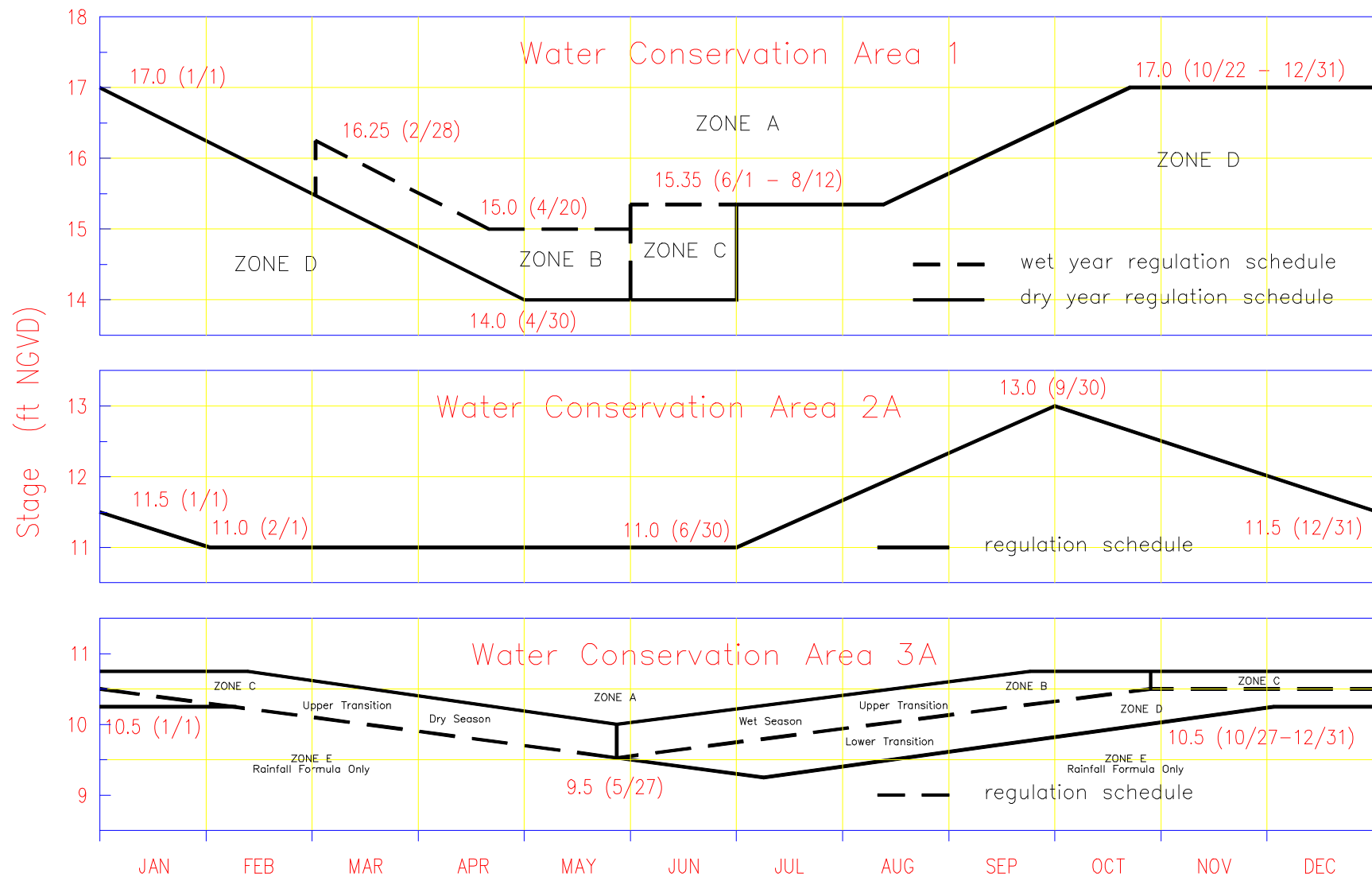




	S-12s	S-333	S-151	L-28 Culverts
Zone A	Open Full	Maximum allowable discharge	Maximum diversion to 3B when 3B stage is less than 8.5 feet	S-343A & B and S-344 open full if no problems downstream
Zone B	S-333 Open: Discharge 45% of target flow S-333 Closed: Discharge at least 73% of target flow (up to 100% if desired by ENP)	Discharge up to 55% of target flow when permitted by this agreement	Same as Zone A whether S-333 is open or closed	Same as Zone A whether S-333 is open or closed
Zone C	S-333 Open: Discharge 45% of target flow S-333 Closed: Discharge 45% of target flow plus all or part of S-333's amount if desired by ENP	Same as Zone B	May be used to divert water from WCA-3A whether S-333 is open or closed	May be used to divert water from WCA-3A whether S-333 is open or closed
Zone D	S-333 Open: Discharge 45% of target flow S-333 Closed: Discharge 45% of target flow plus all or part of S-333's amount if desired by ENP	Same as Zone B	Used only for water supply deliveries to Dade County	Closed
Zone E	Discharge 45% of target flow whether S-333 is open or closed	Same as Zone B	Used only for water supply deliveries to Dade County	Closed

**Figure 3.4.11** Regulation Schedule for Water Conservation Area 3A (adapted from U.S. Army Corps of Engineers, 1992)

(DRAFT Documentation for the SFWMM -- for reviewers only)



**Figure 3.4.12** Regulation Schedules for Water Conservation Areas 1, 2A, and 3A

**Table 3.4.3** Structure Operations Associated with Regulatory Discharges in the Water Conservation Areas

Water Conservation Area	Structure	Headwater (HW)	Tailwater (TW)	Maximum Capacity, cfs	Destination	Operations	Exceptions
WCA-1*	S-10E	Rim canal stage in WCA-1	Stage at col 28 row 46	$416 * (hw-tw)^{0.5}$	WCA-2A	According to operational schedule	
	S-10A C D	Rim canal stage in WCA-1	Stage at col 32 row 42 (S-10A)  col 30 row 43 (S-10C)  col 29 row 44 (S-10D)	$1800 * MAXGO * (hw-tw)^{0.5}$ MAXGO 6.5 ft.	WCA-2A	According to operational schedule	
WCA-2A*	S-144	L-35B borrow canal stage	Stage at col 29 row 37	$140 * (hw-tw)^{0.5}$	WCA-2B	According to operational schedule	
	S-145	L-35B borrow canal stage	Stage at col 30 row 37	$140 * (hw-tw)^{0.5}$	WCA-2B	According to operational schedule	
	S-146	L-35B borrow canal stage	Stage at col 31 row 37	$140 * (hw-tw)^{0.5}$	WCA-2B	According to operational schedule	
	S-11A-C	L-38 borrow canal stage in WCA-2A	Stage at col 27 row 38 (S-11C)  col 27 row 36 (S-11A&B)	$1800 * MAXGO * (hw-tw)^{0.5}$ MAXGO 7.0 ft.	WCA-3A	According to operational schedule	

**Table 3.4.3 (cont.)** Structure Operations Associated with Regulatory Discharges in the Water Conservation Areas

Water Conservation Area	Structure	Headwater (HW)	Tailwater (TW)	Maximum Capacity, cfs	Destination	Operations	Exceptions
WCA-3A	S-151	WCA-3A conveyance canal stage (S-12 hw + 0.4 *slope of conveyance canal)	Stage C-304 in WCA-3B	$700 * (hw-tw)^{0.5}$	WCA-3B	According to operational schedule	When stage in WCA-3B at 3B-29 (col 26 row 26) > 8.9 ft in dry season > 9.0 in wet season
	S-333	WCA-3A conveyance canal stage	L-29 borrow canal in NESRS	$1909 * (hw-tw)^{0.5}$	NESRS	According to experimental rainfall plan	When stage at G3273 (col 24 row 17 ) > 6.8 ft. NGVD
	S-12	WCA-3A conveyance canal stage	L-29 borrow canal in western ENP	$45700 * (hw-tw)^{0.5}$ max. flow = 4800 cfs consider tailwater constraints	Western ENP	According to experimental rainfall plan	
	S - 343AB	WCA-3A conveyance canal stage	Stage at col 15 row 22	390 cfs	col 15 row 22 in BCNP	According to operational schedule	
	S - 344	L-28 borrow canal	Stage at col 15 row 27	135 cfs	col 15 row 27 in BCNP	According to operational schedule	

\* The maximum volume of water the outlet structures can discharge in a day for flood control purposes is the volume required to lower the upstream conveyance canal stage to the maximum of:

1. the bottom elevation of Zone A for current time step minus 0.5 ft. and
2. the minimum elevation of Zone A for regulation schedule: 15.0 feet for WCA-1; 11.0 feet for WCA-2A.

A definition of a WCA floor elevation was given in Sec. 3.1. Stated differently, floor elevation is typically the level triggered by a WCA canal at which the source of water supply to the Lower East Coast Service Area switches from the WCA to another upstream source (e.g., Lake Okeechobee). It is sometimes referred to as WCA minimum level or the level at which discharges are made from WCA to supply water to LEC service areas only if an equal amount is discharged from an upstream source into the WCA. The floor elevations of the different WCAs are shown in Table 3.4.4. Floor elevations are user-input to the model.

**Table 3.4.4** Water Conservation Area Floor Elevations Used in the SFWMM

WCA	Trigger Location	Trigger Stage (ft NGVD)
WCA-1	S10 headwater (same level as 1-8C gage)	13.0
WCA-2A	S11B headwater (same as L-35B stage)	10.5
WCA-3A	S12 headwater	7.5

In order to quantify the total volume of water available from a WCA to meet LEC needs in a given day, the following calculation is done in the model.

$$\text{Vol\_Avail} = \max (A+B+C, 0.0) + D \quad (3.4.1)$$

where:

- A = total net groundwater seepage into WCA conveyance canal assuming canal stage at floor elevation (minimum);
- B = total net overland flow into WCA conveyance canal assuming canal stage is at its minimum;
- C = local canal storage above the floor elevation; and
- D = upstream inflow into WCA conveyance canal.

Table 3.4.5 summarizes the operations associated with WCA outlet structures related to water supply deliveries to LEC service areas.

Two options exist in the model for making water supply releases through multiple WCA outlet structures into a particular LEC service area. They are:

- A. "No Priority" or "equal adversity" option  
In this option, water is delivered proportional to the demands. For each service area, ratio\_ws equals fraction of LEC\_demand to be met from a particular outlet structure such that  
$$\text{ratio\_ws} = \min [(\text{tot\_volume\_of\_water\_available}) / (\text{tot\_demand\_in\_service\_area}), 1.0]$$
and,  
$$\text{flow\_through\_outlet\_structure} = \min [\text{ratio\_ws} * \text{LEC\_demand}, \text{structure capacity}].$$

**Table 3.4.5** Structure Operations for Water Supply Releases from WCAs to LECSAs

Water Conservation Area	Upstream Inflow	Service Area	Outlet Structures	Maximum Capacity (cfs)
WCA-1	EAA runoff thru S5A from WPB canal basin  L8 basin runoff thru S-5Aw and S-5A  EAA runoff thru S6 from Hillsboro Canal Basin  Supplemental LOK releases thru S351 and S6, if needed  Supplemental LOK releases thru S352 and S5A, if needed	Service Area 1 (Eastern Palm Beach County and Northern Broward County)	S5AS into L-8 and M canal  S5AE into C-51  G94 A&B into Lake Worth Drainage District  S39 into Hillsboro Canal & Deerfield Agricultural District	2,000  500  220  $953 \times (\text{hw}-10.5)^{0.5}$
WCA-2A	EAA runoff thru S7 from North New River Canal Basin	Service Area 2 (Eastern Broward County)	S38 into C-14  S-143 and S34 into North New River Canal between S-34 and G-54	$302 \times (\text{hw}-\text{tw})^{0.5}$  $147 \times (\text{hw}-\text{tw})^{0.5}$
WCA-3A	EAA runoff thru S8 from Miami Canal Basin  Western Basins runoff thru S-140A  EAA runoff thru S150 from NNRC basin  Back-pumped flow thru S9 from C-11 in Eastern Broward County	Service Area 3 (Eastern Dade County)	S151	$700 \times (\text{hw}-\text{tw})^{0.5}$

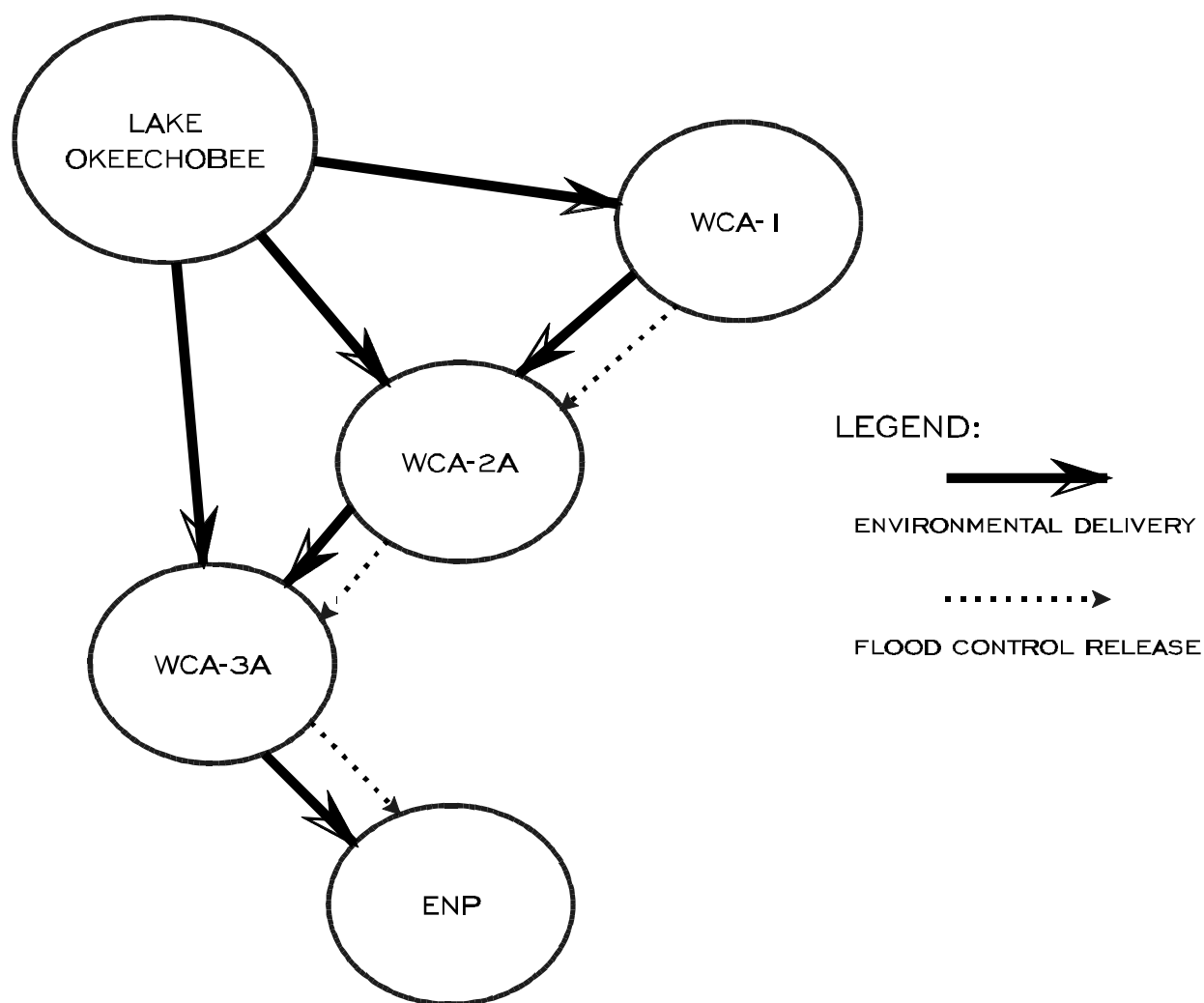
B. Priority option

In this option, the order in which outlet structures are input specifies the priority: structures list first get higher priority. This option can be presented in pseudo-code:

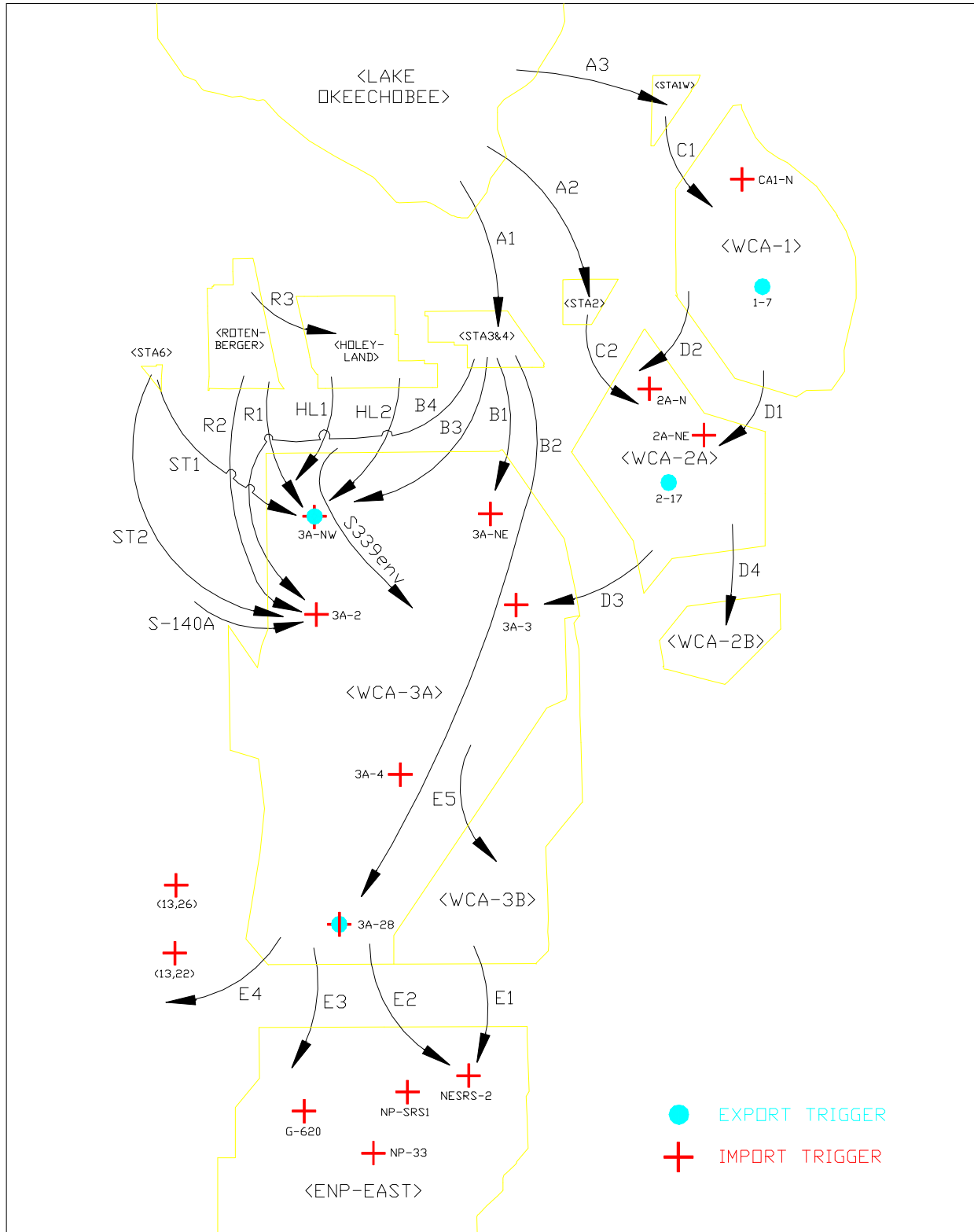
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start_loop: i = 1, number of outlet structures
    flow_through_outlet_structure(i)
    = min[total volume of water available(i), total volume of water needed,
        flow capacity of structure(i)]
```

```
total_volume_of_water_available(i+1)
= total_volume_of_water available(i+1) - flow_through_outlet_structure(i)
end_loop
```

As of this writing, strategies for making environmental deliveries to the Water Conservation Areas exist but have not gone through rule-making. The proposals revolve around modifying WCA regulation schedules to include "environmental" zones, incorporating water supply release rules, selecting environmental trigger locations, and using Natural System Model (NSM) stages, or variations thereof, as target stages. A general model implementation of a proposed operation relating (and coordinating) flood control and environmental releases within the WCAs is shown in Fig. 3.4.13. A more detailed representation of the environmental delivery scheme in the model can be found in Fig. 3.4.14 and Table 3.4.6.



**Figure 3.4.13** Conceptual Diagram of Proposed Operations Associated with Everglades Environmental Deliveries and Flood Control Releases



**Figure 3.4.14** Flow Routing Associated with the Proposed Environmental Deliveries as Implemented in the South Florida Water Management Model



**Table 3.4.6** Description of Proposed Environmental Water Supply Deliveries Within the Everglades

Flow Path	Source	Trigger Location	Destination	Trigger Location (col,row)	Additional Comments
A1	LOK	N/A	STA-3 & 4	3A-NE (23,40) or 3A-NW (18,40) or 3A-28 (19,24)	Flow via Miami Canal in EAA
A2	LOK	N/A	STA-2	2A-N (28,45)	Flow via Hillsboro Canal in EAA
A3	LOK	N/A	STA-1W	CA1-N (30,51)	Flow via WPB Canal in EAA
B1	STA-3&4	N/A	WCA-3A	3A-NE (23,40)	Flow thru gravity structures when stage at 3A-NE is in import zone
B2	STA-3&4	N/A	Conveyance canal in WCA-3A	3A-28 (19,24)	Flow thru S-150
B3	STA-3&4	N/A	NW corner of WCA-3A	3A-NW (18,40)	Assume 50% of gravity outflow toward this destination. Flow occurs if stage at 3A-NE (23,40) is > 0.2 ft. above NSM target
B4	STA-3&4	N/A	WCA-3A via G-404 and thru S-140A via L-4 and L-28 borrow canal	3A-2 (18,36)	Assume 50% of gravity outflow if have B3 100% of outflow if strictly excess flow (B1 & B3 do not occur)
HL1	Holey Land	(20,43)	WCA-3A	N/A	Flow occurs if stage at 3A-NW (18,40) is above NSM target
HL2	Holey Land	(20,43)	NW corner of WCA-3A	3A-NW (18,40)	
R1	Rotenberger Tract	(16,43)	NW Corner of WCA-3A via G-404	3A-NW (18,40)	
R2	Rotenberger Tract	(16,43)	Thru S-140A via G-404, L-4, L-28	3A-2 (18,36)	Flow occurs if stage at 3A-NW is above NSM target
R3	Rotenberger	N/A	Holey Land		Flow occurs if stage in Holey Land is less than 0.2 ft. above NSM target
C1	STA-1W	N/A	WCA-1	N/A	Flow occurs if depth of water in STA-1W exceeds 1.25 ft.
C2	STA-2	N/A	WCA-2A	N/A	Flow occurs if depth of water in STA-1W exceeds 1.25 ft.
D1	WCA-1	1-7 (31,48)	WCA-2A	2A-NE (30,42)	Flow thru S-10A, S-10B and S-10C
D2	WCA-1	1-7 (31,48)	Northern WCA-2A	2A-N (28,45)	Flow thru S-10E

**Table 3.4.6 (cont.)** Description of Proposed Environmental Water Supply Deliveries within Everglades

Flow Path	Source	Trigger Location	Destination	Trigger Location (col, row)	Additional Comments
D3	WCA-2A	2-17 (29,40)	WCA-3A	3A-3 (25,37)	Excess flow occurs if stage at 2A-17 is sufficiently above the NSM stage target
D4	WCA-2A	2-17 (29,40)	WCA-2B	N/A	Excess flow occurs if stage at 2A-17 is sufficiently above the NSM stage target
E1	WCA-3B	N/A	NESRS	Avg. of stages at NESRS-1 (22,20) & NESRS-2 (25,21)	Flow thru proposed S-355 structure
E2	WCA-3A	3A-28 (19,24)	NESRS	Avg. of stages at NESRS-1 (22,20) & NESRS-2 (25,21)	Flow thru S-333
E3	WCA-3A	3A-28 (19,24)	ENP (west of L-67E)	Avg. of stages at G-620 (18,19) & NP33 (20,17)	Flow thru S-12 structures
E4	WCA-3A	N/A	BCNP	Avg. of stages at locations (13, 22) & (13,26)	Flow thru S-343A & B
E5	WCA-3A	Avg. of: (26,33) & 3A-28 (19,24)	WCA-3B	N/A	Flow occurs if the average of stages at (26,33) and 3A-28 (19,24) is sufficiently above average NSM stage target
S-140A	L-28 borrow canal	N/A	WCA-3A	3A-2 (18,36)	Excess flow occurs even if stage at 3A-2 is above NSM target
ST1	STA-6 Outflow	N/A	NW corner of WCA-3A	N/A	Excess flow to NW corner is stage at 3A-2 is above import zone
ST2	STA-6 Outflow	N/A	WCA-3A	3A-2 (18,36)	Flow occurs if stage at 3A-2 is in import zone, otherwise STA-6 outflow is directed to NW corner of WCA-3A
S339env	S-8	3A-NW (18,40)	WCA-3A upstream of S-340	3A-4 (21,19)	If 3A-NW is in Zone A or B (above no action zone), and If 3A-4 is in import zone, open S-339, S-340 stays closed and only opened for LEC water supply

note:

WCA Floor elevations (represented by conveyance canal stages)

WCA-3A (S12HW): Minimum (7.5, 3 gage average [3A-3, 3A-4, 3A-28] of NSM stage targets)

WCA-2A (S11BHW): Minimum (10.5, NSM stage at [29,40] 2A-17 gage location)

WCA-1 (S10HW): Minimum (14.0, NSM stage at [31,48] 1-7 gage location)

If (LOK stage > WCA-1 stage - 1.0, at 1-7) then floor elevation is adjusted to represent simulated water level so that water must come from LOK to meet LEC needs in SA1.

## Rainfall Plan for the Everglades National Park

The rainfall plan is a water management plan designed to benefit ENP by attempting to mimic natural hydrology within the major slough in the park (Shark River Slough or SRS). Specifically, the plan has three objectives: (1) to base the amount and timing of water deliveries to SRS on recent weather conditions (rainfall and evaporation) upstream of the slough, i.e., from WCA-3A; (2) to moderate the sudden changes in flow that were caused by strictly following the regulation schedule for WCA-3A; and (3) to restore flow to the eastern section of North East Shark River slough, thus redistributing flow across the entire slough. The plan has been in effect after a two-year field test conducted from July 1985 to July 1987 revealed positive results. The model includes plan provisions as part of its base run.

In order to accomplish the above objectives, a statistically-based equation to calculate total target flow from WCA-3A to ENP was formulated (Neidrauer and Cooper, 1989). The plan calls for a total target flow equal to the sum of a rainfall-driven component and a regulatory component.

$$Q_{\text{target}}(t) = Q_{\text{rfd}}(t) + Q_{\text{trans}}(t) \quad (3.4.2)$$

The rainfall-driven component was formulated based on a statistical analysis of hydrologic data prior to man-made changes to both spatial and temporal distribution of surface flow into the slough. It relates the current week's flow rate to the previous week's flow rate and the rainfall and evaporation in each of the previous ten weeks. Due to limitations in data availability, the 1941-1952 period of record was selected. The multiple regression formula that resulted from the analysis contains variables expressed in terms of deviations from their respective means.

$$\begin{aligned} q(t) = & CQ [q(t-1)] + CR_1 \sum_{j=1}^2 [r(t-j) - Ke(t-j)] \\ & + CR_2 \sum_{j=3}^6 [r(t-j) - Ke(t-j)] \\ & + CR_3 \sum_{j=7}^{10} [r(t-j) - Ke(t-j)] \end{aligned} \quad (3.4.3)$$

where:

- $q(t) = [Q(t) - Q_{\text{mean}}(t)];$
- $Q(t) = \text{discharge into SRS during week } t, (\text{cfs});$
- $Q_{\text{mean}}(t) = \text{historical mean discharge to SRS for week } t, (\text{cfs});$
- $CQ = \text{lagged flow coefficient, dimensionless};$
- $CR_1, CR_2, CR_3 = \text{lagged rainfall excess coefficient, (cfs/in)};$
- $r(t) = [RF(t) - RF_{\text{mean}}(t)];$
- $RF(t) = \text{rainfall during week } t, (\text{in});$
- $RF_{\text{mean}}(t) = \text{historical mean rainfall for week } t, (\text{in});$
- $K = \text{pan evaporation coefficient};$
- $e(t) = [EVP(t) - EVP_{\text{mean}}(t)];$
- $EVP(t) = \text{pan evaporation during week } t, (\text{in});$

$EVP_{mean}(t)$  = historical mean pan evaporation for week  $t$ , (in); and  
 $t$  = weekly time step.

Therefore, the rainfall-driven component is given by

$$Q_{rfd}(t) = Q_{mean}(t) + q(t) \quad (3.4.4)$$

The regulatory component, on the other hand, is a refinement of the existing schedule for WCA-3A (broken line in Fig. 3.4.11). Thus, transition zone D was included to the schedule as part of the Rainfall Plan. The amount of regulatory discharge prescribed within this transition zone is given by the formula

$$Q_{trans}(t) = 2500 [S(t) - S_{min}(t)]; \quad Q_{trans} \geq 0 \quad (3.4.5)$$

where:

$Q_{trans}(t)$  = regulatory component of discharge when the water level in WCA-3A is in the transition zone, (cfs);

$S(t)$  = water level (WCA-3A 3-gage average) at the beginning of week  $t$ , (ft NGVD);  
and

$S_{min}(t)$  = water level at the bottom of the transition zone (Zone D in WCA-3A regulation schedule) at the beginning of week  $t$ , (ft NGVD).

The coefficient 2500 in Eq. (3.4.5) represents the discharge from WCA-3A at, or near, the capacity of the outlet structures by the time the water level in WCA-3A has reached Zone A.